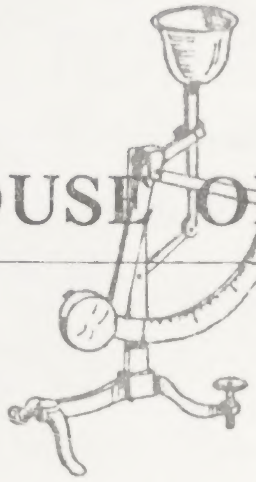
THE HOUSE OF SCALES



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NEWSLETTER MUMBER 16 NOVEMBER 1977

I would Like to use my own Letter Head for my introductory letter, The scale is one drawn by Michael Crawforth from our membership letter, I have a scale like this one.

First of all so I don't forget it Bob Stein called and ask me to have all of you change the address for Mary Baharie her new address is

Mary Baharie
42 The Links,
Whitley Bay,
Tyne and Wear,
England

so don't forget to change it on your membership list. All so he sent lists of 11 new memberships to add to your lists, and that all of you that have sent out your newsletters in the past to please send them a copy.

We started collecting scales about six years ago with one scale made by The Dodge Scale Co. which I paid $5.00 for(Boy them days our gone forever.)Shortly after that I got a hold of an artical wrote by W.A. Scheurer then President of Exact Weight Scale Company, of Columbus, Ohio that he wrote for the 50th National Conference on Weights and Measures, Washington, D.C. June 23, 1965 sponsored by the National Bureau of Standards. (The Science of Weighing Yesterday). Mr. Scheurer has given me premission to use his artical for our newsletters. I am going to do it in two parts. One now and one latter.

This year has been a good year for my wife and I in collecting scales and weights. We have traveled a lot this year and found a lot of nice scales. And our son and his wife went to Japan this past year and found us two sets of opiun weights from Burma, and an opium scale from Japan both from before the 17 th Century. We have also gotten some more Ashanti Gold Weights and a glass weight from the Islandic World.

The first part of Mr Schurer artical is on the history of weights, the second part will be on the history of scales at a later date.

Kenneth W Buck

ISASC
INTERNATIONAL SOCIETY OF ANTIQUE SCALE COLLECTORS
Columbus, Ohio

In the Beginning

When did the science of weighing begin? When did man invent the scale, and a standard system of weights? There are no historical records to show when these momentous events occurred. They are lost in the mists of prehistory, along with those other fundamental devices without which there could have been no civilization: the wheel and axle, the lever, the screw, and the inclined plane.

The oldest known scale is a tiny equal-arm balance found in a prehistoric grave in Egypt--dated roughly at 5000 B.C. This first balance, in use some 7,000 years ago, and less than three and one-half inches long, was carved from red limestone.

And the oldest standard weight? According to the metrologist, Berriman, it is the Mina D. Found in the city of Lagash, in ancient Babylonia, it can be dated at about 2400 B.C. This pear-shaped stone is four inches high and weighs one and one-half pounds. On the other hand, Flinders Petrie claims that some stones found in First Dynasty Egyptian graves were used as weights. If this is true, they were in use around 2900 B.C.

It is of course obvious that the first Egyptian balance would have been useless without weights to measure the loads--and that the Babylonian Mina was used with some kind of scale, even though it is lost to us.

Two Histories: Balances and Weights

These earliest historical remains show that we are confronted by two separate histories: 1) The evolution of the scale, or weighing machine; and 2) The evolution of a standard system of weights.

The history of weights is much less dramatic than that of scales since its whole concern is with the establishment of standard units of comparison. From this standard, larger and smaller units could be derived as specific fractions or multiples of the basic unit. Even the most refined modern weights are quite similar to those ancient ones of thousands of years ago. They differ only in the high degree of accuracy with which the units can be defined and the precise ratios between them. That grandfather of all weights, the Mina, could be used today in the pan balance of our most sophisticated laboratory scales.

The history of the weighing machine itself, however, has been marked by dramatic changes. A modern scale system, with its banks of control panels and hundreds of electronic and mechanical components, has no resemblance to its ancient ancestor of the Nile.

Even so, it is one of the astonishing facts of history that from that first Egyptian balance down to Roman times--about 5,000 years--the equal-arm balance was the only scale in existence. The Roman steelyard, which appeared at about the time of the birth of Christ, was the first new principle in the history of the scale since the beginning of time.

When we consider the phenomenal technical achievements of Egypt, Babylonia, and Greece: their monumental religious architecture of pyramids, zigurrats, and marble temples; their great cities with canals and plumbing; their fleets of ships and armies of soldiers; their complex and effective forms of government and legal codes; and above all their ingenious advances in mathematics and astronomy, we may wonder that they did not discover a new principle in so-important an art as weighing.

But the reason is clear. For the equal-arm balance is still today the most accurate means of comparing a load against a standard unit of weight as witness its extensive use in our most modern scientific laboratories.

Curiosity and Commerce: Double Root of the History of Weighing

With no historical records to the contrary, we may assume that early man first developed a means for weighing objects as a result of his own curiosity about the world around him. He must have looked at the mountain, or the bird, or the tree and said, "How high?" At the running animal, and said "How fast?" At the lake, and said, "How deep?" At the distant forest, and said, "How far?" And he must have picked up many a stone and said, "How heavy?" He could find the answers only by devising standard units of weight and measure.

The satisfaction of intellectual curiosity has been perhaps the chief motivation for all of our great scientific discoveries. But the development of civilized life demanded standard units of weight and measure. There can be no extensive commerce between peoples without some form of reference and comparison which will visibly demonstrate the equity of the transaction. That first Egyptian balance is testimony to the need for some more objective standard than the human senses.

Man the Measure

At the beginning of the first civilizations, man himself became the original measuring device. He found that his own limbs could provide a crude but satisfactory linear measure. From his body he developed such units of measurement as the digit, thumb, palm, hand, span, cubit, yard, fathom, foot and pace. These proved so convenient that, in spite of their obvious variability, some of them are still used today.

But it was a different matter with weights. There was nothing about the human body which offered a visible means for judging differences in weight. To compare weights, early man could rely only on his sense of "heft"--a method so arbitrary as to be almost useless in commerce or construction.

From Tote Pole to Balance

With no history to guide us, we can only assume that the first great step towards a system of weights and measures was derived from the "tote pole," or coolie yoke. Undoubtedly some primitive, but clever, fellow first learned that a heavy load could be carried more easily if it were divided, and each part hung from the ends of a pole slung across the shoulder. The more balanced the loads, the easier it was to carry them.

From the tote pole it seems to us now but a step to the equal-arm balance. By suspending the pole at its center, the load hanging from one end could be balanced against some standard hung from the other. And with this first great step we have come to the beginning of the history of weighing.

The Three Basic Scale Components

Every weighing system, from the most primitive to the most modern, consists of three basic elements: 1) the load receiver; 2) the load sensor; and 3) the readout. Looking once again at the primitive Egyptian balance, the cord suspended from one end of the beam is the load receiver--that part of the scale which holds the load to be weighed. From the opposite end of the beam is suspended the load sensor--in this case a weight against which the load is compared. And in this primitive balance the only readout is the eye which must judge when the load is exactly balanced by the sensor. No matter how complex or ingenious our modern scale systems, they all incorporate these three basic elements of weighing. And the history of the science of weighing is the story of man's progressive ingenuity in discovering methods for conveniently holding all types of loads; more exact load sensing devices; and more accurate, faster systems of readout.

After 7,000 Years

The science of weighing depends upon one simple function: accurate comparison with a standard unit. The increased accuracy of comparison, the increased standardization of the units, will measure our progress. And how far have we come after 7,000 years? There are in use in the world today some 5,000 basic and derived units of weight, measure, and capacity. Many backward countries still use quite primitive systems of weights, having an accuracy perhaps no greater than one part in a hundred. But the instrumentation in the more technologically advanced countries provides an accuracy to one part in many millions. The number of different units is not so important. It is accuracy of comparison which counts. When we can say that one meter equals 1.093613 yards, or that one pound equals 0.45359237 kilograms, this is science. When we can say that the U. S. bushel equals 0.9689 British bushels, and that this in turn is equivalent to 35.2381 liters, our technology has realized the goal of accuracy in scientific measurement, accuracy of comparison with standard units.

Today we measure accurately the length of a lightwave, or of a gamma ray, in terms of the Angstrom unit, one ten billionth of a meter in length. Or we can measure that much of our universe which is known to us through our radio and light telescopes--and here the standard unit is the light year, a linear unit five trillion, 878 billion miles long. We can weigh the tiniest known physical particle, the electron--and find that it is 1/910,700,000,000,000,000,000,000,000,000 of a gram (one 910,700 billion billion

billionths of a gram). Or we can measure the weight of our own earth, and find that it is six billion billion grams. These illustrations show how far we have progressed since that first Egyptian balance.

I. The Evolution of Weights

The Westward Course of the Evolution of Weight Systems

The history of weights shows several significant trends. In the first place, while almost all primitive societies have, and have had, some system of weights, it is only that group of highly developed civilizations which can claim the development of exact standards. Each of these civilizations arose from small beginnings to astonishing heights of cultural and technical achievement, creating powerful empires and great world cities, and then declined to comparative insignificance, overcome and superseded by other rising civilizations. The earliest of these great cultural units appears to have been the Babylonian civilization, or, more properly, the Sumerian-Akkadian. This first civilization began its organized evolution in the Tigris-Euphrates valley around 3,000 B.C.

About a century later, the second great civilization--the Egyptian--began its recorded evolution in the Nile valley. For more than a thousand years, as far as we know, these were the only civilizations on our planet.

About 1500 B.C., the Indian civilization was shaping itself in the Indus valley, and several centuries later the great Chinese culture appeared in the East.

From that time onward the rise of new civilizations followed a generally westward course. Around 1200 B.C., the Hittite-Assyrian civilization grew to power north and west of the old Babylonian. About the same time the Hebrew civilization spread over Palestine.

In the years around 1100 B.C. the Graeco-Roman, or Classical, civilization grew up on the Greek mainland and the islands of the Ionian and Aegean Seas. This powerful civilization, which died with the fall of the Roman empire, was succeeded by the Byzantine-Arabic civilization. Arising much farther east, around 200 B.C., this culture spread westward and dominated the whole of the Near East and a considerable portion of Europe until the 15th century A.D.

Still moving westward, the Western civilization began to grow from the remains of Charlemagne's loosely constructed empire, about 900 A.D.

But even before Western civilization began, far to the west across the Atlantic Ocean, there appeared the Maya civilization in Mexico, and the Inca civilization in Peru--both around 500 A.D.

At the same time that the great American civilization was beginning on the North American continent, the ancient oriental civilizations of India and China were being superseded by another, half-oriental, half-European: The Russian, which was beginning to take on a semblance of unity after the territorial acquisitions of Ivan the Terrible in the 15th century and Peter the Great in the late 17th.

What is significant for us here is that each of these great civilizations developed its own system of weights, and each, in general, retained their system in spite of the gradual spread of universal commerce.

The Rise of Standard Weight Systems

Throughout this long and shifting pattern of historical evolution, with its continual rise, expansion, and fall of great civilizations, there appears another central tendency: the gradual unification of hundreds of local systems of weights within a civilization into a general system of standards established by a central government. For example, the 17 known standards of early Egypt were reduced to eight over the course of the centuries.

While stone weights apparently were the first standard units, the cereal grain became the smallest unit of weight in many of these civilizations--a unit still used today. It was generally stipulated that the standard grain should be chosen from the center of the ear, and dried. While grains of uniform size made a fairly reliable, and universal, unit of weight, they varied according to the amount of moisture they absorbed. Today, there are 7,000 grains in the pound avoirdupois and 5,760 grains in the troy pound.

Babylonian Weights

Looking briefly at the various systems devised by the great civilizations, we find the Mina and the Shekel to be the basic units of the Babylonian system. The previously mentioned Mina D weighed 1.5 pounds. The Mina N weighed 2.16 pounds. Archaeologists have also found weights of five Minas, in the shape of a duck, and a 30-Mina weight in the form of a swan.

The Shekel, familiar from the Bible as a standard Hebrew coin and weight, was one of the most ancient Babylonian weights, and was equal to 0.036 pounds, or a little more than half an ounce. In Babylonian terms, the Mina N was equal to 60 Shekels.

Egyptian Weights

Historical evidence of Egyptian weight systems is much more extensive than the Babylonian. The basic Egyptian system appears to have been founded on the Sep, the Deben, and the Kedet (or Kite). The ratio was 1 Sep = 10 Debens = 100 Kedets. However, there were many different Kedets, ranging in weight from about 70 to 292 grains. This system of standard ratios only appeared after Egyptian civilization was well advanced. In an earlier age, the gold Deben itself was the basic unit. Much later the Kedet became the standard reference.

About 3,400 different weights have been recovered from ancient Egypt, some in simple geometric shapes, others in a wide variety of human and animal forms.

Indian and Chinese Weights

Very little has been discovered about any extensive Indian weight system and still less about the ancient Chinese. Some 288 specimens of stone weights have been found in the Indus valley excavations. Although they are without rating marks, they range in mass from 1.5 to 135 grams. Since these series of cubic stones decrease in size in an orderly pattern, it is clear that the early Indians had a standard system of weight units. Centuries later there are many references to the Retti seed as a fundamental unit of weight.

The early development of a coinage system by the ancient Chinese is a clear indication that they also possessed standard weights. One such unit, the Kin, has persisted through history--a gold unit equal to one cubic inch of this metal.

Hittite-Assyrian, Hebrew, and Phoenician Weights

The Hittites, Assyrians, Phoenicians, and Hebrews derived their weight systems generally from the old Babylonian measures, and occiasionally from the Egyptian.

Hebrew standards were based on the relationship between the Mina, the Talent, and the Shekel. The Sacred Mina was equal to 60 Shekels, and the Sacred Talent to 3,000 Shekels, or 50 Sacred Minas. The Talmudist Mina equalled 25 Shekels; the Talmudist Talent equalled 1,500 Shekels, or 60 Talmudist Minas. Since the Shekel was equivalent to one-half ounce, the Sacred Mina weighed 30 ounces, and the Sacred Talent about 94 pounds.

The historian Josephus mentions a Jewish tradition that Cain, after his wanderings, built the city of Nod and became the inventor of the system of weights and measures. There is some merit to this view in light of the fact that Cain's original difficulty came about through his inability to convince God of the equivalence in value between fruit and sheep.

The First Decimal System

During this same period, about 1,000 B.C., the Babylonians began to use the first decimal system of weights and measures. It had its origin in the Egyptian lineal measure, the Mahi, or length of the forearm. The Babylonians took the Half-Mahi as a measure of sizes and weights for containers. The Half-Mahi was divided into ten parts, each equal to one Thumbreadth. One cubic Half-Mahi thus contained 1,000 cubic Thumbreadths, and the weight of water filling a container of this size was reckoned at 1,000 Bekas. Two smaller units were then derived from this basic unit the Scruple, equal to one-tenth Beka, and the Grain, equal to 1/200th Beka. Referring to a previous system, 100 Shekels = 64 Bekas.

The Greek Weight System

By this time in the evolution of civilizations, there was extensive land and maritime commerce among the peoples of the Near East and southern Europe. As the Greeks began to build a civilization on the shores of the Aegean and in Asia Minor, they adopted and modified the Babylonian decimal plan. The Greek cubic foot, or Pous, became the base of the system.

Since the Greek foot was equal to 12 Thumbreadths, the cubic Pous equalled 1,728 cubic Thumbreadths, or a similar number of Bekas. Or, since one Beka = 12 Scruples, one cubic Pous = 17,280 Scruples. The Greeks then divided this into smaller units: 17,280 Scruples = 60 Litra Weights; one Litra weight = 12 Twelfth Weights; one Twelfth Weight = 8 Dram Weights; one Dram Weight = 3 Scruples; one Scruple = 20 Grains.

Roman Weights

As the Greek culture was merged with, and superseded by, the rising Roman empire, the Romans altered the Greek weight system by calling the Twelfth Weight an Uncia--from which is derived our word "ounce." Moreover, they set 16 Uncia equal to one Pondus, later to become our avoirdupois pound. Sixty Pondus weights were then reckoned to be the weight of one cubic foot of cool water.

Modifying another weight system, the Romans set 12 Uncias equal to one Libra, and 80 Libra equal to the weight of one cubic foot of cool water. This 12-ounce pound became the basis of the Troy system.

Arabic Weights

As the great Roman Empire fell into decay, first the Byzantine, then the Arabic and Turkish civilizations took its place as the leading cultures. Now still another system of weights came into use but we know very little about the ancient Arabic standards. The barleycorn became the basic small unit of weight, and Yusdruman pound used by the Arabs was derived from the Bablyonian Mina. It was adopted by Charlemagne and remained for years the standard pound of medieval France. The Arabic, or Mohammedan, Michtal equalled 1/72 Egypto-Roman Pound, and 100 Michtals equalled one Rotl, equivalent to 7,283 grains. This Rotl became the basis of the old Germanic weight system.

The Avery Collection* contains a set of glass coin weights with rating marks of great accuracy, indicating the high standards reached in the Arabic weight systems.

The Evolution of European Weight Systems

Although the Roman empire established its system of weights and measures over great parts of the world, the rising European states in the Middle Ages never fully adopted it, and some countries retained their own local standards. Italy and France used the basic Roman weights and ratios, while England, Germany, Holland, Denmark, Sweden, and Norway used native measures.

Around 850 A.D. Alfred the Great brought considerable uniformity to the standard weight units of England. The prevailing English measure of capacity was a container one hand-breadth long in each dimension. The weight of water filling this container became the basic weight unit: the Measure Weight. The set of derived units then was: one Tun Weight = 1000 Measure Weights; one Measure Weight = 1000 Skeats; One-Half Measure Weight = one Scale Weight; one Hundred Weight = 100 Scale Weights; the Half-Hundred Weight = 50 Scale Weights; and the Stone Weight = 1/8th Hundred Weight.

*London, England.

A Revolution: The Prototype Standard

At this moment in world history a great step was taken towards more accurate weight standards. Rather than each English community constructing its own basic weight unit by rough guess, it borrowed the national standard from the royal government and made an exact duplicate of it in iron. As far as we know, this is the first instance of what might be called the Prototype Standard. The standards were carefully kept, by order of the Saxon kings, at Winchester. After the Norman conquest in 1066, William the Conqueror determined to preserve the Anglo-Saxon system of standard weights and had the prototypes moved to Westminster Abbey.

The recognition of the need for standard units of weights and measures was so great that the famous Magna Carta of 1215 stressed the principle of uniformity. Somewhat later, Henry III redefined the traditional Saxon monetary unit of the pound, known as the "pound sterling" because the English penny was called a "pence sterling." The ratios were: one pound = 20 shillings; one shilling = 12 pence--the system still used today. Also, 20 pence = one ounce, and 12 ounces = one pound. The English pound sterling had the same divisions as the <u>livre</u> <u>esterlin</u> of Charlemagne, unifier of Europe in the 9th century.

In 1303, when London had become one of the great trading cities of Europe, the London merchants were empowered to install a new pound weight system, consisting of 16 ounces to the pound, and called <u>aver-de-peis</u>, meaning "weight of goods" (later corrupted to its present form of <u>avoirdupois</u>). It was not from intent but from coincidence that the new English pound nearly equalled the weight of the Italian pound, called the Libra; and the English Ounce was almost identical in weight to the Italian Onzia--the Italian system having been derived from the Roman. This is why today our abbreviation for the pound is <u>lb</u> and <u>oz</u> for the ounce.

Even before the introduction of the avoirdupois system, many English port cities were using another set of units for weighing precious metals, jewelry, and drugs. This was the Troy system used by the Hanseatic Leaque of north German and Baltic cities which was rising to a dominant position in maritime commerce. Exact weight was so important to Hanseatic trade that its scales were specially made in Nurnberg, and the set of weights was based on the German Onze, or Troy Ounce. The Troy system itself may have taken its name from the town of Troyes in France, center of the great Champagne Fairs, most famous of all medieval European trading regions.

The Hanse maintained outlying settlements in four big cities, one of which was London. This part of the city was called the "Steelyard." It is not known whether it took this name because of the metal-loading docks or because of the huge steelyard used to weigh heavy goods.

The Londoners referred to these German traders as "Easterners" or "Easterlings"--later shortened to "Sterlings." Consequently, the Luebeck coins were called <u>sterling</u> <u>silver</u>; the ounce was the <u>sterling</u> <u>ounce</u>; and the pound was the <u>pound</u> <u>sterling</u>.

In the 19th century, the Troy system was abolished in England, with the exception of the Troy Ounce of 480 Grains, used to weigh previous metals and stones.

The Great Metric Revolution

Following the westward course of the history of weighing, we observe a continuation of the same two trends which have threaded the whole development of weight standards: 1) The constant rise of different sets of standard units, often resembling each other, and 2) the tendency to simplify the number of units by the direction and control of a central government. Yet the only significant advance towards the goal of increasing accuracy was the English establishment of a prototype standard, and its duplication by the various communities throughout the country.

While this was an epoch-making improvement, it did nothing to establish a universal system to be used throughout the world by all peoples. Moreover, like almost all other systems of the past, its units involved fractions. What was needed was a system in which weights, measures, and volumes were immediately related by units which were always the same fraction or multiple of a single base unit.

Of all of the upheavals occasioned by the French Revolution of 1789, the most important for the history of weight measurement was the invention of the metric system. This system, adopted by France in 1790, was the first plan ever to relate measure, weight, and volume by the same units, each of which was the same multiple or fraction of a base unit. This basic standard was named the meter (from the French "to measure") and the derived units were decimal multiples or fractions of this standard unit of length. The meter was defined as one ten millionth of a quadrant of the earth's circumference.

The exact length of the meter was to be determined by measuring the difference in latitude between Dunkirk, France and Barcelona, Spain. After that was done, a standard meter bar was constructed. However, due to a slight error, it was found that the distance on the earth's surface from the Equator to the North Pole was not exactly ten million units of the new meter, but slightly more. But it was now too late to change the system. In 1875, the International Bureau of Weights and Measures was established, and prepared a platinum-iridium alloy bar on which two fine marks were made, the distance between them defining the standard length of the meter. This International Prototype Meter is kept at Sevres, a Paris suburb, and exact copies of it, called National Prototype Meters, are in the possession of governments of various countries.

To a great extent, the Metric System marks the fulfillment of man's long search for a universal standard of weights and measures. It is an invention almost as significant as the weight itself.

Weights in the United States

The systems of weights and measures in the United States are similar to those of Great Britain, with some variations. A resolution of Congress in 1836 approved the units adopted by the Treasury Department in 1832, which endorsed the avoirdupois pound of 7,000 grains. While Congress has never actually adopted these standards, they are in general practical use throughout the country. Congress further stipulated that each of the States was to be supplied with a complete set of weights and measures. This was accomplished by 1850. This set also included the troy pound of 5,760 grains.